FUTURE REPAIR AND MAINTENANCE
FOR AEROSPACE INDUSTRY

Deliverable 3.3 **Parts lifecycle cost comparison**

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Executive summary

The extensive long product life cycle of aircrafts leads to the need to reduce the operation costs which is additionally driven by the fact that airlines have to maximize the utilization rate of their high value investments.

The applied product life cycle model incorporates all phases from the product idea to the recycling of a part while the focus is on the operation phase as this is the longest and most cost intensive part with up to 25 years. Due to the fact that 20 to 40 years of production have to be added and approximately 10 years of development, this sums up to 75 years for an aircraft series with the need for spare part supply. Consequently, the products and technologies used are at some point outdated and offer the potential for an update to gain benefits. Due to high certification effort, this is only reasonable for certain parts.

In general, life cycle costing is based on the follow-up costs of an investment which are often higher than the acquisition costs. They are essential for a holistic economical overview. The approach is not only product specific but takes into account also all periods of a product. It enables a long-term strategic decision based on to be expected costs for a specific product. Therefore a model based on the DIN 60300-3-3 (2005) has been applied which divides the life cycle into six phases: concept and definition, design and development, manufacturing, installation, operation and maintenance as well as disposal. The focus is on the operation and maintenance phase whereas parts that exhibit lower life cycle costs usually require a higher effort during the design and concept phase.

The market analysis has shown that the airline’s costs structure is dominated by fuel costs with almost 60% of the total costs. The second largest cost contributor is the maintenance and repair of the aircrafts with a share of 16%. The engines require the most intense maintenance and are the largest cost driver within maintenance. The material costs for repair and maintenance are extremely high in comparison to the personnel costs and the external repair costs. The analysis regarding the fuel consumption for an extra kilogram weight disclosed a huge spread between the values of different literature statements. Different aircrafts and transport networks affect the information as well as imprecise data. Nevertheless a relation between weight and fuel consumption can be observed. In summary, this implies that a lightweight design and low priced, durable parts are the key factors to reduce the operation costs.

These two influence factors depend partially on the manufacturing technology and its characteristics. Therefore they have been analyzed. Subtractive technologies are limited in the design complexity of the part but are able to provide parts exhibiting very high material properties which lead to a high durability and thus decreasing maintenance and repair costs. Parts manufactured by subtractive technologies usually do not require any finishing or post-processing effort and this shortens the manufacturing chain and makes it less complex. Shaping technologies are able to manufacture more complex geometries which feature lightweight parts to decrease the fuel consumption. But the part properties can be influenced negatively by bubbles and residues and the forms to manufacture parts are cost intensive. Additive technologies produce layer-by-layer without any shaping tools which enables a cost-efficient, highly complex part production. Hence, the function integration into one part allows for a lightweight design that facilitates several advantages for the operation costs.

Additionally, parts can be optimized for their purpose and not for manufacturing. Currently, this technology is limited in its availability and quality which hampers the qualification for aerospace. Nevertheless, it shows a huge potential as the lightweight design decreases the fuel consumption and the lower number of parts reduces the maintenance and logistics effort as the handling complexity is decreased. Less spare parts have to be available and because of the cost-efficient single part production that can be achieved by AM, only a small number of spare parts have to be stocked. All of this decreases the costs for maintenance and spare parts and overall the operation costs. A comparison table identifies these differences and explains their impact on the operation costs.

The impact of a lightweight part design is shown with a use case. A lever designed for milling has been chosen as a sample part and a topology optimization is conducted in order to get to the optimal part design for the defined load cases. Thereby, a weight reduction of 43% could be achieved. This part design is only producible by AM so that both designs and their correspondent manufacturing technology are analyzed with regard to the complete product life cycle costs. For AM, the design and development phase is more expensive due to the higher effort for the optimization. The production costs are also considerably higher than for milling the traditional design. Nevertheless, the AM design saves more than 43% in operation costs. Due to the long life cycle of an aircraft and the huge impact of fuel savings, this sums up to overall cost savings for this part of about 40%. This may be highly part depending and assumptions had to be made for the calculation but in general the use case shows that the potential for lightweight parts, which are usually not producible by conventional manufacturing, is high and can be exploited by AM.